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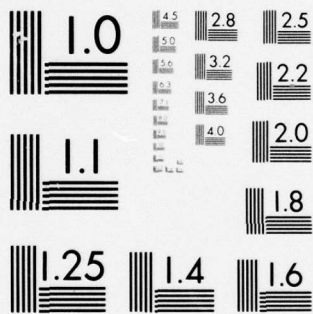
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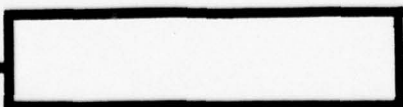
by

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PULSE CODE - DATA TRANSMISSION

E. Balcke , H. Reck, and K. Gerbig

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INTRODUCTION

Electronic information technology is faced with the task of dealing with the constantly increasing need for information transmission. The technical, economic, and commercial conditions which underlie the design of the currently existing information networks have changed considerably. Therefore an exclusively quantitative expansion of the facilities and equipment now available can offer no sure solution for the future. **Just** the rising number of telephone and teletype terminals and the increase in the volume of the traffic flow require the rapid improvement of information communication systems. Several approaches can be proposed on the basis of the technical state reached by transmission and switching technology. The following criteria, among others, are very significant for their initiation and evaluation:

- The expanded and qualitatively higher requirements and

needs of the customers must be met. These include toll-line dialing throughout the system, with increased switching and transmission safety and quality as well as expansion of the customer service with improvement of operating comfort, etc.

- The technology for preparing modern electronic and electrooptical components permits manifold application of digital technology and enables the implementation of a high degree of automation for the entire operating process in transmission and switching units under economically justifiable conditions.

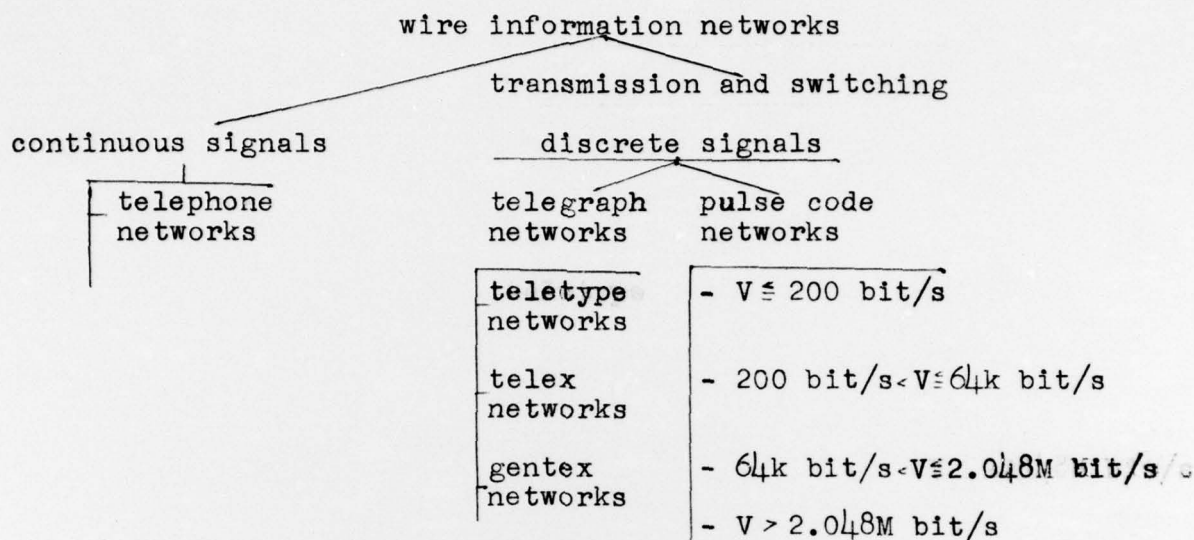
- As a still developing type of information transmission of but recent appearance data transmission requires the attention appropriate to it with its specific features.

The development of the existing telecommunication equipment and facilities into an information system satisfying the prospective requirements can be realized only gradually and over a long period of time. This system must encompass the greatest range of possibilities for information transmission. The transmission and switching processes must be extensively integrated in it; analog and digital techniques must be intercorrelated etc. The utilization of the present telephone and telegraph networks is a significant secondary condition, since they are highly developed and at the present time represent the bulk of the facilities of any postal administration.

1. DATA TRANSMISSION OVER WIRE NETWORKS

Data transmission involves the transmission of information in the form of digital signals with specific technical parameters. An optimal layout of the transmission channels can be undertaken with special data networks which are exclusively tailored to the interests of data transmission and which make possible the transmission and communication of data from the source to the user in digital form. Until the creation of such data networks data transmission must take place over the available information paths, which necessarily leads to certain compromises.

It is natural to subdivide the existing information networks into those for the transmission and communication of continuous (analog) and discrete (digital) signals.(Fig. 1). Here it must be considered that a networks essentially consists of transmission and switching arrangements. In addition, there are, for example, transmission arrangements which transmit both continuous and discrete signals and those which can transmit only specific discrete signals. Consideration also must be given to the fact that at the present time the signals for the different networks are, and in the future also can be, transmitted over one transmission path (subscriber's line, telephone cable).



V: bit speed of the digital data flows

Figure 1. Wire Information Networks Usable for Data Transmission

Both the telephone networks and the telegraph networks, as is well-known, are used for data transmission with the corresponding auxiliary equipment.

1.1. DATA TRANSMISSION OVER THE TELEPHONE NETWORKS

The transmission channel and switching facilities of telephone technology are designed for the transmission of analog signals. Their use for data transmission is possible if the data signals usually existing in binary form are transformed correspondingly into analog carrier frequencies with a transducer. A significant advantage of this data transmission lies in the fact that, on the one hand, the telephone network is

accessible for a large range of users because of its branching and that, on the other, any telephone connection with the appropriate data terminals can be used for telephony and for the transmission of data.

The most essential facilities required for this type of data transmission ^{are} the MODEM, the equipment for securing data, and the switching equipment.

The modulation and demodulation equipment (MODEM) serve for converting the binary data signals into carrier frequency continuous signals and back. At the same time interface conditions must be achieved in order to match the data processing conditions with the information technology in the telephone network. These are established internationally in the V and X recommendations of the CCITT according to the speed classes of the data transmission (200 bit/s; 300 bit/s; 600 bit/s; 1200 bit/s; 2400 bit/s; 4800 bit/s; 9600 bit/s; 20,000 bit/s; and others).

Because of the electromechanical switching devices and so forth the analog network produces relatively high frequencies of error, so that data-securing equipment has to be used. These data securing devices can be interposed on the analog and digital side.

Error detectors which determine and signal whether the transmission channel is functioning error-free or not from the

amplitude, phase, and/or frequency of the received signal are unused on the analog side.

On the digital side the data signal is coded appropriately in order to secure data, that is, redundant elements are added. Special equipment also performs control of the longitudinal parity, the transverse parity, and the cross parity or a control with the base code (cyclic coding). The quality and economy of the data transmission to a great degree determined by the error protection process chosen (error recognition or error correction) and by the degree of reduction of error probability required.

Certain procedures which must be accomplished with the telephone apparatus are required for bringing about the connection and for arranging specific conditions for data transmission between two terminals.

1.2 DATA TRANSMISSION OVER THE TELEGRAPHY NETWORK

In their time behavior data elements most correspond to telegraphy symbols. The existing telegraphy networks therefore also are suited for data transmission under certain conditions. Practical applications are limited primarily to direct transmission corresponding to the processes of direct-current telegraphy for speeds of up to around 200 Bd, or alternating

current telegraphy devices are used.

At the present time there is no tendency shown for this type of data transmission to be further developed for long-distance communication.

1.3. DATA TRANSMISSION OVER PULSE CODE NETWORKS

The networks designated in Fig. 1 as pulse code networks are intended to characterize those systems, ~~part~~ subsystems, devices, and facilities which permit transmission and exchange of data signals in digital form. They are intended to work isochronously by themselves and are capable of working anisochronously together with other systems or subsystems of data and information handling. The subdivision into the speed ranges given also appears justified with respect to the pulse code modulation (PCM) technology.

2. DIGITAL DATA TRANSMISSION OVER PCM SYSTEMS

PCM techniques make a time multiplex transmission of binary signals possible and therefore can also be used for data transmission. The starting point for the development of the PCM systems was the time-multiplex utilization of transmission channels for telephony. The technical parameters of the PCM systems therefore result from conditions which obtain in the

case of the transmission of speech channels. Relatively high speeds with bit rates of 64 kbit/s and with bit speeds of 2.048 Mbit/s are established in the PCM channels of the 30/32 channel system. These can only be viewed as economical for data transmission if the data sources provide flows with the appropriate speeds or if short transmission times are required in the case of a greater flow of data to be transmitted with lower speeds. To be sure, data flows with lower bit rates also can not be transmitted directly over PCM channels.

Since the bit rates of the PCM channels are 64 kbit/s, submultiplexers, which assume the processing of the "slow" data flows which may exist, must be installed both in the PCM terminals and in the PCM main exchanges (Fig. 2). The submultiplexer as a rule must be another synchronous terminal inasmuch as the slow data are supplied to it and removed from it asynchronously. The increasing need for economically justifiable terminal transmission and exchange equipment which are tailored to the interests of "slow" data transmission, i. e. data flow speeds under 64 kbit/s, is manifested particularly in the case of the internal data transmission in businesses as well as in the case of public data communication.

A brief look at a projected data transmission system is presented below. This system is particularly suited for slow digital data flows but its design permits it to be used for

medium-speed and fast data flows without any further modification.

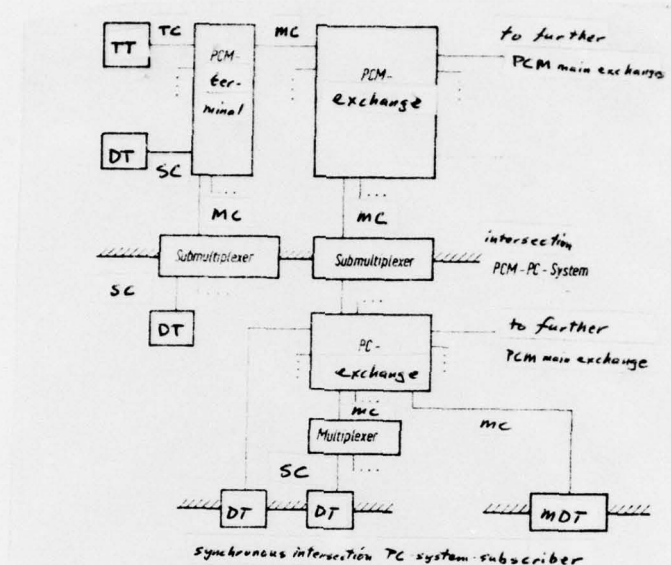


Figure 2. Orienting Network Structure for PCM and for PC Data Transmission. DT Data Terminal; TT Telephone Terminal; MDT Multiple Data Terminal, e. g. Electronic Data Processing Unit as a Subscriber; SC Subscriber Channel; MC Multiplex Channel; TC Telephone Channel; PC Data Channel with $V = 64$ kbit/s.

3. DESCRIPTION OF THE PULSE CODE DATA TRANSMISSION SYSTEM

The pulse code data transmission system (PC system) /1/ includes the entire complex of the terminal and exchange equipment required for the communication from terminal to terminal as well as transmission channels, the data flows being transmitted digitally and synchronously. The PC system can be used both as an autonomous system as well as a subsystem for the PCM system. Data flows, the speeds of which are lower than or equal to a V_M multiplex speed, are transmitted and exchanged.

The following criteria are decisive for the PC system:

- the possibility of fully or partially automatic communication through centralized or decentralized control units;
- the use of time multiplex transmission and exchange processes;
- the achievement of all connections for duplex traffic for bidirectional communication between two data terminals;
- the synchronization of all centralized and decentralized equipment belonging to the system;
- code transparency for the information to be transmitted;
- speed variance in the sense that different but discrete working speeds are allowed;
- the possibility of correspondence between different data terminals in "off line" and in "on line" operation inasmuch as the data terminals provide the data flows with the same operating speed;
- the establishment of connections in the main exchanges through electrical switching networks operating with space and time splitting;
- guaranteeing a sufficient basic error protection and higher reliability for many users;
- furnishing economically advantageous terminals for the users; and
- compatibility with the 30/32 channel PCM system, and, in general, with any PCM system.

In this way the expansion of the hierarchy of the PCM family

which up to now has been considered to be primarily a higher channel system is being expanded downward through a subsystem.

The overall structure of the PC system is shown in Fig. 2. The data terminals are connected with the main exchange either through subscriber channels or through decentralized data multiplexers and multiplex channels. The subscriber channels consist of spatially separated branch lines which transmit the data flows with the bit speeds supplied from the terminals.

The use of the decentralized data multiplexer assumes that a sufficiently large number of data terminals with a corresponding territorially differentiated traffic flow exists which results in and justifies the expenditure for time multiplex utilization of the transmission channel to the main exchange. Fig. 2 does not explicitly show the possibility that the decentralized data together with the data terminals represents a larger data processing unit, the DT in practice being formed by the channels of the data processing unit (MDT). The decentralized data multiplexers are characterized by a relatively simple, stably operating construction. No exchange functions are assigned to them and the gating of the subscriber channels into the time allocation of the multiplex framework takes place according to a specific arrangement. The data multiplexers take care of both the multiplexing for the channels in the direction of the main exchange as well as the demultiplexing of the channels leading to the terminals.

Both the subscriber channels and the multiplex channels can, in practice, be realized with the telephone cables already available. In general, data communication without error recognition or correction devices will be possible because of the low bit error frequency to be expected.

In the PC main exchanges subscriber and multiplex channels run from data terminals which belong to the main exchanges; in addition, multiplex channels with a variable arrangement of channels can be connected with the time positions, which lead either to further PC main exchanges or to submultiplex units, which, in addition to ^{performing} speed transformation of the data flows, also must meet the interface conditions for matching the PC system with the PCM system.

The most important components of the PC main exchanges are the central control, which is operated by a control computer or (in the case of relatively low numbers of subscribers) by a register control, and the data path network for connecting through the data channels. The entire operation is controlled according to an algorithm and makes it possible to have automatic communication between two or several data terminals and an electronic data processing unit which is connected with the PC system over a multiple data terminal as a subscriber (data bank, order computer, etc.).

The data path network contains spatially and temporally separated coupling fields with the switching and memory equipment for connecting-through as well as the necessary time allocation conversions and decentralized control equipment.

Further stages in the construction of the data path network, such as channel signal receivers, target address receivers, and symbol generators perform the functions which are necessary for making and breaking connections.

4. SUMMARY

The expansions and qualitative changes in information networks required for meeting future requirements must also take account of the interests of data transmission to a greater degree than is now the case. Data transmission over the existing equipment and transmission channels used for telephony and telegraphy is fundamentally possible but it leads to certain compromises. Utilization of the PCM systems for data transmission offers favorable solutions in the case of relatively high bit speeds, but in the case of relatively slow data flows it can not always be viewed as economically defensible.

The basic features of the pulse code data transmission system were presented as an economical approach, particularly for the synchronous transmission and exchange of slow to medium-

speed digital data flows. Its technical parameters and its structure make it possible to use it in different variants both as a subsystem for a PCM main system and as a regionally autonomous data transmission system in non-public areas. As in the case of the carrier frequency MODEM technique, telephone lines are used as data subscriber's lines. Data and conversation can be transmitted simultaneously if the data transmission is limited to certain operating speeds.

LITERATURE

- [1] Balcke, E., Gerbig, K., u.a.: Das Pulscod-Datenübertragungssystem, ein System zur Übertragung und Vermittlung digitaler Signale. Nachrichtentechnik 24 (1974) H. 9, S. 351-353.

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